Saddleback Ridge Wind, LLC // Natural Resource Protection Act (NRPA) and Site Location of Development Act applications

- *Exhibit 1 (AR-05) Nissenbaum Testimony and Exhibits*

July 1, 2011

- Michael Nissenbaum, MD – testimony
- Michael Nissenbaum, MD – testimony attachment (exhibit F – black and white)

AR-05

STATE OF MAINE
BOARD OF ENVIRONMENTAL PROTECTION

In Re:

PROPOSAL TO AMEND DEPARTMENT OF ENVIRONMENTAL PROTECTION RULE 375.10 ON CITIZEN PETITION PURSUANT TO 5 M.R.S.A. §8055.3	))))	**TESTIMONY OF MICHAEL A. NISSENBAUM, MD**

1. I give this testimony in support of the Citizen Initiated Petition to amend the DEP Noise Rule based on my concerns as a physician about adverse health effects from wind power projects that are licensed under the existing Noise Rule.

2. In brief, my credentials for my testimony are that I am a Medical Doctor, Board Certified in Diagnostic Imaging, whose training includes extensive medical physics and the physics of energy deposition in human tissues, including ionizing radiation, radio frequencies, and sound. I am subspecialized in Magnetic Resonance Imaging, with additional experience and interest in neuroimaging including functional brain imaging (the imaging of brain activation in response to various stimuli). I am a past faculty member (junior) of Harvard Medical School. Over the last 3 years, I developed an interest in and researched issues relating to the human response to noise arising from Industrial Wind Turbines, a new developing area of clinical inquiry. I designed and completed the world's first two controlled studies of potential adverse health effects related to noise arising from Industrial Wind Turbines, both of which are submitted for publication. I have been accepted as an expert in the subject in various jurisdictions. Also, I was an invited participant, along with Dr. Robert McCunney, to a joint discussion/presentation of our respective perspectives on IWT's and Health, at Rutland Regional Hospital in Vermont in May of 2010, the first time a hospital in North America has organized an event on this subject.

I am a founding board member of the Society for Wind Vigilance, a non-profit organization comprised of physicians, physiologists, and acoustics experts whose mission is to provide a scientific clearinghouse for the analysis of scientific information appearing in published documents created by Industry, Government, and the Scientific Community on the subject. I am a coauthor of the analytic documents published by the Society. Some of the publications we have placed into the public domain are listed on the accompanying Curriculum Vitae, a copy of which is attached as *Exhibit A.*

3. I developed my an interest in the health effects of wind turbine projects after becoming aware of complaints related to an industrial wind turbine project in Mars Hill, Maine. Following a small pilot study in 2009 at Mars Hill, I undertook a larger, standardized study in 2010 in the towns of Mars Hill and Vinalhaven (Fox Island Wind Project) Maine. Both of these studies have been submitted for publication.

4. The following is a summary of my study and conclusions in the larger Mars Hill/ Vinalhaven study:

a. Validated questionnaires were administered to 79 subjects living between 375 and 6600 meters from industrial wind turbines (IWTs) at two sites. Sleep quality (Pittsburgh Sleep Quality Index - PSQI), daytime sleepiness (Epworth Sleepiness Score - ESS) and general health (SF36v2) were assessed together with demographic data and change in psychiatric symptoms, headache, nausea and dizziness. The study followed a strict protocol including subject and control selection criteria, with raw data segregated from and not handled by the principal investigator. Data analysis was carried out by a professional epidemiologist, who did not interact with either subjects or controls.

b. Subjects living within 375-1400m (38) were compared with those living

3.3-6.6km from IWTs (41). Those living within 1.4km had significantly worse sleep (assessed by Pittsburgh Sleep Quality Index (PSQI)), were significantly sleepier during the day (assessed by Epworth Sleep Scale (ESS)) and had significantly worse SF-36v2 Mental Component Scores. Significant dose response relationships between PSQI, ESS, SF36 Mental Component Score and log-distance to nearest IWT were identified after controlling for gender, age and household clustering. There were no significant differences between the two sites. There was a significant increase in use of prescribed psychotropic medications for those living within 375-1400 meters compared to those living farther away.

c. This study supports the anecdotal reports of sleep disturbance and ill health from those living close to IWTs, which are remarkably similar from multiple sites around the world. The dose-response (distance-effect) relationship seen at Mars Hill and Vinalhaven is strong evidence of a causative relationship between IWT noise and ill health. Current permitted setback distances at these sites are too close for protection of the human population.

d. The study of Mars Hill and Vinalhaven presented to the BEP today has been peer reviewed and found valid by epidemiologists, physicians practicing in public health, and other physicians on 3 continents. It has been accepted for presentation at three Scietific Meetings. The structure of the study, including the pattern of questionnaires used, is, I am told, to be replicated in studies to be performed in Canada, the UK, the USA, and Australia.

5. Based on my medical background and experience, and the Mars Hill/Vinalhaven Study, it is my professional opinion that there is a high probability of significant adverse health effects for residents whose homes are located within 1400 meters (.87 miles) of industrial turbines. The health risks include:

a) Sleep disturbances/sleep deprivation and the multiple illnesses that cascade from chronic sleep disturbance. These include cardiovascular diseases

mediated by chronically increased levels of stress hormones, weight changes, and metabolic disturbances, including the continuum of impaired glucose tolerance up to diabetes.

b) Psychological stresses which can result in additional effects including cardiovascular disease, chronic depression, anger, and other psychiatric symptomatology.

c) Increased headaches.

d) Unintentional adverse changes in weight.

e) Auditory and vestibular system disturbances.

f) Increased requirement for and use of prescription medication.

7. Based on my studies and medical background and experience, it is my further professional opinion that any future industrial wind projects in Maine should build in an additional margin of safety to avoid the kind of adverse health effects experienced at Mars Hill and Vinalhaven. I recommend, preliminarily, a setback distance of at least 2000 meters (1.25 miles), or a distance determined by an appropriately designed preconstruction sound modeling targeting nighttime sound levels of 35dBA at the building façade or property line, whichever is greater.

8. There is not a single, non-industry funded study or any peer reviewed literature that states that wind turbine noise is harmless to human health. To the contrary, there is an emerging body of literature, some of which is peer reviewed, informing us that under certain circumstances wind turbine noise can have substantial physiological and psychological impacts on a community. In support of this statement, I attach as *Exhibit B* a summary of some of the literature on this subject composed by Daniel Shepherd, PhD from the Auckland University of Technology in New Zealand. Many of the references in Dr. Shepherd's work are already in this rulemaking record, which record also contains updates to his references.

9. At this point in time, the industrial wind industry does not appreciate or fails to acknowledge the progression of how new environmental toxins are evaluated by the medical community. To quote Dr. Shepherd:

> Wind turbines are a new source of community noise, and as such their effects on public health are only beginning to emerge in the literature. The recognition of a new disease, disorder, or threat to health usually follows a set pathway. First, doctors and practitioners attempt to fit symptoms into pre-defined diagnostic categories or to classify the complaints as psychosomatic. Second, as evidence accumulates, case studies begin to appear in the literature, and exploratory research is undertaken to obtain better descriptions of the symptoms/complaints. Third, intensive research is undertaken examining the distribution and prevalence of those reporting symptoms, the factors correlating with the distribution and prevalence of those symptoms, and ultimately to cause-and-effect explanations of why those reporting symptoms may be doing so.
>
> In my reading of the literature the health effects of wind turbines are only beginning to be elucidated, and is caught somewhere between the first and second stage described in 2.3. The important point to note is that case studies (e.g., Harry, 2007; Pierpont, 2009) and correlation studies (e.g., Pedersen et al., 2007; van den berg, 2008) have already emerged in relation to the health effects of wind turbine noise, and so the possibility of detrimental health effects due to wind turbine noise must be taken with utmost seriousness.

10. The short, medium, and long term effects of sleep disturbance and sleep deprivation have been long understood, and are a basic tenet of the most rudimentary medical education. Still, understanding of the precise physiology and documentation of the effects continues to advance. Chronic sleep disturbance can be expected to affect almost every bodily system through its effects upon the brain and endocrine systems. Both physical and psychological deleterious effects can and do occur, as validated by my Mars Hill/Vinalhaven study and medical literature .

11. As it is known that sleep disturbance will over the medium and long term result in

adverse health effects, the only 'proof' required in this setting is to demonstrate that IWT's placed in proximity to dwellings results in ongoing sleep disturbance, in order to prove that IWT's in proximity to dwellings result can result in adverse health effects.

12. Illogically, some people have elected to try and delegitimize the application of these known bodies of knowledge to the issue of IWT's, as if known effects of noise and sleep deprivation have to be proven all over specifically with regard to IWT's prior to basic protective legislation being put into place. This is analogous to the deleterious effects of a school bus accident being devalued because there is no 'published, peer reviewed' data describing injuries directly as a cause of school bus accidents, even though it is understood that motor vehicle accidents in general can result in injury.

13. In their recent publication, entitled 'Wind Turbine Sound and Health Effects: An Expert Panel Review, December 2009', the American and Canadian Wind Energy Associations acknowledge that wind turbine facilities can create annoyance for nearby residents, but then seeks to belittle the significance of this fact. While the word "annoyance" has been used in European studies relating to this turbine noise, the term has been presented in the above document to imply an inconsequential disturbance, whereas the authors meant something else entirely. A reading of the original papers upon which proponents of the wind industry base their opinions that "annoyance, only, may occur" quickly reveals that a more appropriate word in American English would be "disturbance" rather than the colloquial American English understanding of the word "annoyance" as an inconvenience of minor significance. In fact, the lead author of many of these studies (Eja Pedersen, PhD), erroneously quoted and interpreted by the wind proponents and the above referenced industry publication, stated to me in a personal communication that:

> "Annoyance is a response, rather than an effect. However, to be annoyed means a lowered well-being and annoyance should therefore be avoided. The relationship between annoyance and symptoms of lowered health goes, from what I have found in my studies, two ways.
>
> People who have lowered physical or mental health are more vulnerable and therefore get annoyed.
>
> People who get annoyed may not get the physiological and psychological restoration that they need and annoyance could hence increase the risk for impaired health."

14. "Annoyance" in the context of industrial wind energy facilities is not only a critical physiologic stressor in its own right, but is shown, unequivocally to cause sleep disturbance at both Mars Hill and Vinalhaven. When sleep disturbance is chronic, which it is in the case of turbines sited too close to dwellings, it results in sleep deprivation. Sleep deprivation will result, as surely as day follows night, in a host of adverse symptoms and, over time, diagnoses of frank illness. This includes headaches, changes in weight, psychiatric symptoms, cognitive dysfunction, possible increases in blood pressure, and the like in the near and medium term. Chronic sequela must necessarily include illnesses such as diabetes and heart disease, which are know to occur in the chronically sleep deprived at increased frequency compared to those who are not sleep deprived. This is not conjecture. This is simple, known, medical fact.

15. A review of the Mars Hill and Vinalhaven findings suggests that this "annoyance" ('disturbance', more properly) is one of the root causes of the sleep disturbances and secondary adverse health effects suffered. Mechanisms for how intrusive noise affects health are summarized in the diagram from the WHO *Guidelines for Nightime Noise in Europe* (2009) attached as *Exhibit C* hereto, which reflects longstanding and non-controversial, settled medical knowledge. The findings of the WHO *Guidelines* are attached hereto as *Exhibit D*. There is no statement in the WHO *Guidelines* that the disease thresholds summarized in the foregoing charts are dependent on exposure for a year to observe all of the listed effects and there is nothing in the

scientific literature that requires such a long exposure. Adverse health effects can be observed after only a few days of sleep disturbance. They are not dependent on exposure for a year and there is nothing in the scientific literature that requires such exposure. Chronically impaired sleep over a period of time, much shorter than one year, results in adverse health effects.

16. Annoyance, in addition to being addressed in the WHO *Night Noise Guidelines for Europe 2009 and Guidelines for Community Noise 1999*, has been studied extensively by Swedish wind noise expert, Dr. Eja Pederson, and her colleagues in publications that are already a part of the rulemaking record.

17. Therefore, if one is to look to the WHO *Guidelines* in order to determine what levels of noise would generally be safe, those limits would be set somewhere between 30 dBA and 40dBA, with a margin of safety from the lower threshold.

18. In addition to adverse health effects secondary to sleep interruption, residents living nearby to wind projects propagation noise at 45 dBA at night will deprive these residents of health related quality of life. It is an accepted public health tenet that vectors that diminishes health and well being or that result in negative psychiatric symptomatology result in reduced health related quality of life. That this occurs in relation to IWT's has been demonstrated by Pedersen et al, Shepherd et al, in studies made part of the rulemaking record and in the Mars Hill/Vinalhaven study presented here (as the SF-36v2 component of the study is considered a 'quality of life' measure within medicine). There is absolutely no question that the quality of life of the affected residents of both Mars Hill and Vinalhaven has been seriously diminished.

19. It is well established today that noise generated from the operation of wind turbine projects is unique and significantly different from noise generated from other common industrial and commercial operations, including traffic, rail and air transportation, as illustrated by the

graph published by Eja Pederson in 2004 attached hereto as *Exhibit E*. Because of certain characteristics, Industrial Wind Turbine Noise is proven, decibel for decibel, to be more disturbing than noise from any other industrial source people are exposed to in their residential environments.

20. The reasons for this difference include: (a) amplitude modulation of audible sounds, which is pulsating (or 'impulsive') in nature and therefore more "disturbing" than other kinds of noise. (b) a dominance of dynamically modulated infrasonic and lower frequency acoustic energy, which can more easily penetrate facades of buildings and can convert through building resonance sound that is otherwise inaudible into noise that is audible, intrusive and disturbing to most people, (c) noise being emitted from high above the ground resulting in a pervasive and omnipresent character that dominates the soundscape, and (d) noise which is often a persistent source of disturbance compared to noise from more common sources such as railroads and airports, and has therefore an increased potential to casue adverse effects on the adjacent community's health and welfare than sounds generated from other sources for which the current regulatory scheme for noise in Maine was developed.

21. Finally, I disagree with the assertions that compliance with the Sound Level Limits of the DEP Noise Rule of 45 dBA at nighttime in a quiet, rural environment adequately protects against exposure to excessive noise from wind turbine projects for the following reasons:

a. The current 45 dBA limit specified in the DEP Noise Rule is too high for rural and wilderness communities. The DEP Noise Rule does not address the higher annoyance and disturbance effects caused by the unique and pervasive noise of wind turbines. It does not take into consideration the impact on rural and wilderness communities with naturally low background sound levels, especially at nightime, which results in a level of noise, when measured in decibel level, significantly over and above the pre-development community noise levels in these rural communities, and of sufficient amplitude, when sited in close proximity to

homes (such as has occurred at Mars Hill and Vinalhaven) to result in adverse health effects.

b. The DEP Noise Rule does not require any measurement or control of infrasonic and low frequency noise propagated by wind turbine projects which can cause adverse public health consequences even at levels that are not audible to many people.

d. The DEP Noise Rule does not take into account amplitude modulation, a feature of wind power noise that is an important component of its uniquely disturbing quality.

e. It is possible for a noise emitter to produce continuous noise during a night that results in sound levels between 40 and 45 dBA that exceed WHO's 40 dB ($L_{night-outside}$) thresholds where observable adverse health effects are known to occur, yet be in compliance with the DEP Noise Rules.

22. To supplement my testimony, I attach a series of power point slides as *Exhibit F,* which I will partially address at the rulemaking hearing.

Dated: June 30 , 2011

Michael A. Nissenbaum, M.D.

Curriculum Vitae - Michael A. Nissenbaum, MD

Address: 194 E. Main St., Fort Kent, ME 04743

Citizenship: Canadian / American

Positions Held:

1998-current:	Solo Radiologist, Northern Maine Medical Center, Fort Kent, ME
1994-1998	Chief, MRI Clinical Services, MRI Scan Center, Ft. Lauderdale, FL
1992-1994	Associate Director to Bob Edelman, MRI, Beth Israel Hospital, Boston, MA, (Harvard Medical School)

Education:

1979	McGill University, Faculty of Arts and Science (Honours Anthropology)
1983 M.D.	University of Toronto, Faculty of Medicine

Postdoctoral Training:

Internships, Residencies, Clinical Fellowships:

1984-1988	Resident, Radiology, McGill University Faculty of Medicine, Montreal, Canada
1983	Intern, Internal Medicine, Mount Sinai Hospital, Toronto, Canada
1988	Armed Forces Institute of Pathology, Washington, DC
1991-1992	MRI Clinical Fellow, Long Beach Memorial Medical Center, Long Beach, CA Supervisor: William G. Bradley, Jr., M.D., Ph. D.

Research Fellowship:

1990-1991	Interventional Research Fellow, University of California at San Diego, CA

Licensures and Certifications:

1984	Quebec License Registration
1986	Ontario License Registration
1989	California License Registration
1991	Massachusetts License Registration
1994	Florida License Registration
1988	Fellow, Royal College of Physicians of Canada
1986	Diplomate, American Board of Radiology
1988	Diplomate, Quebec Board of Medical Specialists (Radiology)
1998	Maine Medical License

Academic Appointments:

1992-94	Harvard Medical School, Boston, MA.

Hospital Appointments:

1989-1990	Attending Radiologist, Alexandra Hospital, Ingersoll, Ontario.
1991-1992	Clinical Fellow; Memorial Medical Center, Long Beach, CA.
1992- 1994	Attending Radiologist, Associate Director of MRI, Beth Israel Hospital, Boston, MA
1998-present	Attending Radiologist, Northern Maine Medical Center

Awards and Honours:

1977, 1978, 1979	McGill Scholar –McGill University
1977, 1978, 1979	James McGill Award – McGill University
1988	Chief Resident, Royal Victoria Hospital

Memberships, Offices and Committee Assignments in Professional Societies:

American Roentgen Ray Society - L
Canadian Medical Association
American College of Radiology - L
Radiological Society of North America - L
Associate Member, American Society of Neuroradiology - L

Teaching Experience:

1990	Percutaneous Ethanol Ablation of Hepatic Neoplasia: Tissue Responses, Physiological Effects, and Imaging Characteristics in the Normal Liver, Dept. of Rad. Research Conference, Univ. of CA at San Diego
1991	Interventional Radiology, University of California at San Diego
1991-1992	Monthly Lecturer MR Visiting Fellowship, MRI Instruction to Radiology Residents, University at Irvine Memorial MRI Educational Institute
1992	Lecture: MRA- Current State-of-the-Art. To: Grand Surgical Rounds, Department of Surgery, Beth Israel Hospital, Harvard Medical School. Nov 1992
1993	Lecture: MRI Update: New Diagnostic Applications. To: Internal Medicine Group, Beth Israel Hospital, Harvard Medical School. October 1993
1993	Lecture: Optimization of Magnetic Resonance Angiography. To: Brigham and Womens' Hospital MRI and CT Update: October 1993, Harvard Medical School
1994	Lecture: Advanced MRI Techniques. To: Department of Radiology, Chinese University Hong Kong. December 1994
1995	Ongoing Lectures: Topics in Neurological and Body MRI and MRA (AMA category 1 credits) monthly at MRI Scan Center, Ft. Lauderdale, FL

Editorial Responsibilities:

1992-98	Reviewer, MRI related topics. American Journal of Roentgenology

Principal Clinical and Hospital Service Responsibilities:

1992-94	Associate Director, MRI, Beth Israel Hospital, Boston, MA.
1994-98	Chief, MRI Clinical Services and Advanced MR Applications MRI Scan Centers, Ft. Lauderdale, FL

Grant Support:

Seed grant for Tumor Ablation Research, Canadian Radiological Foundation Research Award (1988-1989).

Imaging Guided Tumor Ablation Project, Academic Senate of the University of California (1990-1991).

Principle Investigator: AMI-25, Superparamagnetic Iron Oxide Contrast Agent for use in Assessment of Hepatic Malignancy. 1991-1992 at Long Beach Memorial Medical Center
(Corporate-sponsored, non-peer reviewed)

Bibliography

Original Reports:

1. **Nissenbaum MA,** Jequier S. Enlargement of Adrenal Glands Preceding Adrenal Hemorrhage. JCU. 1988; 16:349.

2. Wei L, **Nissenbaum MA,** Stehling MK, Goldmann A, Edelman RR. Differentiation between Hemangiomas and Cysts of the Liver with Nonenhanced MR Imaging: Efficacy of T2 Values at 1.5T. JMRI 1993

3. Muller MF, Prasad P, Siewert B, **Nissenbaum MA,** Raptopoulos V, Edelman RR. Abdominal Diffusion- Mapping Using a Whole Body Echo Planar System. Radiology, August 1993.

4. Ros PR, Freeny PC, Harms SE, Seltzer SE, Davis PL, Chan TW, Stillman AE, Muroff LR, Runge VM, **Nissenbaum, MA.** Hepatic MR Imaging with Ferumoxides: A Multicenter Clinical Trial. Radiology, August 1995.

Books and Monographs:

1. **Nissenbaum MA,** vanSonnenberg E, D'Agostino HB. Interventional Radiology in the Liver, Biliary Tract, and Gallbladder. In: Schiff E, ed. Diseases of the Liver. J.B. Lippincott Company, 1993. pp 279-298.

2. **Nissenbaum MA,** Adamis MK. Magnetic Resonance Imaging in Rheumatology- An Overview. In: Rheumarology Clinics of North America. Trentham, ed. May 1994.

3. **Nissenbaum MA.** MRI of Bone Marrow Disease, In Magnetic Resonance Imaging. Edelman and Hesselink, 1995.

Abstracts:

1. **Nissenbaum MA,** Atkinson DJ, Song SJ, Brown SM, Yan K, Widoff BE, Blitzer J, Bradley WG. Metastic Lesion Detection in the Liver; Increased Sensitivity of Dynamic Ultrafast MRI. Society for MRI in Med. 1992;

2. **Nissenbaum MA,** Margossian P, Song SJ, Brown SM, Widoff BE, Yan K, Amster JL, Bradley WG. Increases Sensitivity of Black Blood MRA: A Role for Optimized Sequences? Society for MRI in Med. 1992;

3. **Nissenbaum MA,** Palmer N, Widoff BE, Song SJ, Brown SM, Yan K, Amster JL, Bradley WG. MRI of the Post Operative Lumbar Spine: The Value of Gadolinium Enhanced Multiplanar Reconstruction Using 3D Acquired Datasets Yielding 1MM Isotropic Resolution. Society for MRI in Med. 1992;

4. Brown SM, **Nissenbaum MA,** Atkinson DJ, Song SJ, Widoff BE, Yan K, Kurzweil PR, Jackson D, Bradley WG. MR Arthrography with Contrast Enhancement (MR ACE): Evaluation of Articular Cartilage in the Knee. Society for MRI in Med. 1992;

5. Brown SM, Atkinson DJ, **Nissenbaum MA,** Song SJ, Widoff BE, Yan K, Kurzweil PR, Jackson D, Bradley WG. Kinematic MRI of the Knee with Biplane Acquisition. Society for MRI in Med. 1992;

6. Bradley WG, Atkinson DJ, Nitz WR, **Nissenbaum MA,** Song SJ, Widoff BE, Yan K, Brown SM. Quantitative CSF Velocity Imaging: Comparison of Normals and Patients with Shunt-Responsive NPH. Society for MRI in Med. 1992;

7. Bradley WG, Brown SM, Widoff BE, Yan K, Song SJ, **Nissenbaum MA.** Analysis of Aneurysms and AVM's Missed on Routine MR Images which are Detected by MR Angiography. Society for MRI in Med. 1992;

8. **Nissenbaum MA,** Atkinson DJ, Brown SM, Song SJ, Widoff BE, Yan K, Bradley WG. Avoiding T1 Contrast Variability in IR Prepped Ultrafast Imaging Using Breath Holding. Society for MRI in Med. (1992).

9. **Nissenbaum MA,** Palmer N, Widoff BE, Brown SM, Song SJ, Yan K, Amster JL, Bradley WG. Assessments of the Lumbar Spine Using 3D Acquisition Sequences Providing 1mm Isotropic Resolution: The Value of Multiplanar Reconstruction. Society for MRI in Med. (1992).

10. **Nissenbaum MA,** Brown SM, Song SJ, Widoff BE, Yan K, Bradley WG. Decreased Intensity of Pathology in the Left Lobe of the Liver on T2 Weighted Imaging Related to Pulsation Induced Intravoxel Dephasing: Implications for Clinical Imaging. Society for MRI in Med. (1992).

EXHIBIT B

A SUMMARY OF RESEARCH UNDERTAKEN ON WIND TURBINE NOISE*

Preamble

There are now a number of studies showing that turbine noise is annoying, and that there is a link between annoyance to turbine noise and health as defined by the WHO. A brief description of this evidence is now listed, and where possible, technical jargon has been omitted or minimised. It should be noted that, without exception, all of these studies have shortcomings, and indeed, research of this type is vulnerable to inherent limitations that serve to dampen its impact. However, the studies selected represent credible researchers undertaking difficult research.

Harry (2007)

Dr Amanda Harry, a British General Practitioner, conducted surveys of 42 residents living near several different turbine sites and reported a similar constellation of symptoms from all sites. Of the 42 respondents, 81% felt their health had been affected, in 76% it was sufficiently severe to consult a doctor and 73% felt their quality of life had been adversely impacted. This study is open to criticism for a design that invited symptom reporting and was not controlled. While the proportion of those affected may be questioned it nevertheless indicates strongly that some members of the public are severely affected by wind turbine noise at distances thought by governments and industry to be safe.

Harry, A. (2007), Wind Turbines, Noise and Health. Retrieved from: http://www.flat-group.co.uk/pdf/wtnoise_health_2007_a_harry.pdf

Pedersen et al., (2003, 2004, 2007, 2008 and 2009)

Pedersen and co-investigators have undertaken a series of investigations examining the relationship between turbine noise and health. In a 2004 paper (n=351) Pedersen reports the importance of individual and contextual factors alongside noise parameters, and the danger in generalising findings from other sources of community noise (e.g., road, rail, aircraft) to the wind turbine context (see Figure 3.0, mainbody). In a 2007 paper (n=754), Pederson further explores these individual and contextual influences. They noted that those living in rural areas are more likely to be annoyed than those from suburban areas, and that those living in complex terrain (e.g., hills or rocky terrain) were more likely to be annoyed than those living on flat ground. The study found a strong association between annoyance and both lowered sleep quality and negative emotions. A paper

published in 2008 (n=1822) reanalysed pre-existing turbine noise and annoyance data and concluded that turbine noise can impede health, especially for susceptible individuals. The paper also discussed the dangers of using noise level as a sole predictor of annoyance, and the strength of noise sensitivity indices in predicting annoyance.

Pedersen and others (2009) reported that annoyance increased with increasing sound levels, both indoors and outdoors (see Table 1). The proportions who were rather and very annoyed at different sound levels are shown in Table I. In summary, when outside, 18% were rather or very annoyed at sound levels of 35-40 and 40-45 dB(A) compared to 7% at 30-35 dB(A) and 2% at <30 dB(A). When inside, the equivalent figures were 1% at <30 dB(A), 4% at 30-35 dB(A), 8% at 35-40 dB(A) and 18% at 40-45 dB(A). Those respondents who had an economic interest in the turbines had lower levels of annoyance while negative views of the visual impact of turbines increased the likelihood of annoyance.

Although the authors do not seek to recommend minimum sound levels, they do note that turbine noise was more annoying than other sources, with the possible exception of railway shunting yards and was more noticeable at night. Reported associations between annoyance and symptoms of stress (headache, tiredness, tension and irritability) confirmed that "annoyance" is more than irritation and is a marker of impaired health. They conclude that (Pedersen et al, 2009):

"...night time conditions should be treated as crucial in recommendations for wind turbine noise limits."

Nevertheless, it is clear from this analysis that external predicted turbine sound levels should be less than 35 dB(A), considerably less than those permitted by European noise standards, in order to reduce effects on nearby residents to acceptable levels.

Table 1: Percent responding to level of annoyance towards outdoor and indoor wind turbine noise levels for five categories of level in 5-dB(A) sound level intervals. Parentheses present 95% confidence intervals. (From Pedersen 2009)

	Predicted *A*-weighted sound pressure levels dB(A)				
	<30	30–35	35–40	40–45	>45
Outdoors	n=178	n=213	n=159	n=93	n=65
Do not notice	75 (68–81)	46(40–53)	21(16–28)	13 (8–21)	8(3–17)
Notice, but not annoyed	20 (15–27)	36(30–43)	41(34–49)	46 (36–56)	58(46–70)
Slightly annoyed	2 (1–6)	10(7–15)	20 (15–27)	23 (15–32)	22(13–33)
Rather annoyed	1 (0–4)	6(4–10)	12 (8–18)	6 (3–13)	6(2–15)
Very annoyed	1 (0–4)	1(0–4)	6 (3–10)	12 (7–20)	6(2–15)
Indoors	n=178	n=203	n=159	n=94	n=65
Do not notice	87 (81–91)	73(67–79)	61(53–68)	37 (28–47)	46(35–58)
Notice, but not annoyed	11(7–17)	15(11–20)	22 (16–29)	31(22–31)	38(28–51)

Slightly annoyed	1 (0–4)	8(5–12)	9 (6–15)	16 (10–25)	9(4–19)
Rather annoyed	0 (0–2)	3(1–6)	4 (2–8)	6 (3–13)	5(2–13)
Very annoyed	1 (0–4)	1(0–4)	4 (2–8)	10 (5–17)	2(0–8)

Pedersen, Hallberg, and Waye (2007) conducted in-depth interviews with 15 people living within close vicinity of wind turbines. A qualitative method known as grounded theory was selected to inform both data collection and data analysis. Respondents opinions of the turbines and the turbine noise was largely determined by their personal values about the living environment. The feeling of intrusion was associated with feeling a lack of control, subjected to injustice, a lack of influence, and not being believed. Various coping strategies were engaged, such as rebuilding their houses or complaining. Most however displayed learned helplessness and simply tried to ignore wind turbine noise.

Pedersen, E., Hallberg, L.R.M., and Persson Waye, K. P. (2007). Living in the Vicinity of Wind Turbines - A Grounded Theory Study. Qualitative Research in Psychology, 4: 1, 49 – 63.

Pedersen, E., and Nielsen, K.S. (1994). Annoyance due to noise from wind turbines. Delta Acoustic and Vibration Ltd. Report 150, Copenhagen, Denmark.

Pederson, E. W. (2005). Human Response to Wind turbine Noise – Annoyance and moderating factors. Wind Turbine Noise: Perspectives for control, Berlin, INCE/European Conference.

Pedersen, E., and Persson Waye, K. P. (2004). Perception and annoyance due to wind turbine noise: a dose-response relationship. Journal of the Acoustical Society of America, 116(6), p3460-3470.

Pedersen, E., and Persson Waye, K. (2007). Wind turbine noise, annoyance and self-reported health and well-being in different living conditions. Occupational Environmental Medicine, 64, p480-486.

Pedersen, E., and Waye, K. P. (2008). Wind Turbines – low level noise sources interfering with restoration? Environmental Research Letters, 3, 1-5.

Pedersen, E., van den Berg, F., Bakker, R., and Bouma, J. (2009). Response to noise from modern wind farms in The Netherlands. Journal of the Acoustical Society of America. 126:634-643.

van Der Berg (2008)

van den Berg and colleagues (2008) from the University of Groningen in the Netherlands have recently published a major questionnaire study of residents living within 2.5km from wind turbines. A random selection of 1948 residents were sent a similar questionnaire to that used by Pedersen in her studies in Sweden (2003, 2004, 2007 and 2008), questions on health, based on the validated General Heath Questionnaire (GHQ), were added. 725 (37%) replied which is good for a survey of this type but, nevertheless may be a weakness. Non-respondents were asked to complete a shortened questionnaire. Their responses did not differ from full respondents suggesting the latter are representative of the population as a whole.

Questions on wind turbine noise were interspersed with questions on other environmental factors to avoid bias. The sound level at the residents' dwellings was calculated, knowing the turbine type and distance, according to the international ISO standard for sound propagation, the almost identical Dutch legal model and a simple (non spectral) calculation model. The indicative sound level used was the sound level when the wind turbines operate at 8 m/s in daytime, that is, at high, but not maximum power. Noise exposure ranged between 24 and 54 dB(A). It is worth noting that the industry was approached for assistance in the research but refused. Complaints such as annoyance, waking from sleep, difficulty in returning to sleep and other health complaints were related to the calculated noise levels.

The research team concluded that *"Sound was the most annoying aspect of wind turbines"* and was more of an annoyance at night. Interrupted sleep and difficulty in returning to sleep increased with calculated noise level as did annoyance, both indoors and outdoors. Even at the lowest noise levels, 20% of respondents reported disturbed sleep at least one night per month. At a calculated noise level of 30-35 dB(A), 10% were rather or very annoyed at wind turbine sound, 20% at 35-40 dB(A) and 25% at 40-43 dB(A). van den Berg concluded also that, contrary to industry belief, road noise does not adequately mask turbine noise and reduce annoyance and disturbance. Bolin (2009) has shown that vegetation noise does not mask turbine noise as well as expected. With regard to health it was concluded that:

"There is no indication that the sound from wind turbines had an effect on respondents' health, except for the interruption of sleep. At high levels of wind turbine sound (more than 45 dB(A)) interruption of sleep was more likely than at low levels. Higher levels of background sound from road traffic also increased the odds for interrupted sleep. Annoyance from wind turbine sound was related to difficulties with falling asleep and to higher stress scores. From this study it cannot be concluded whether these health effects are caused by annoyance or vice versa or whether both are related to another factor."

Though the conclusion appears to contradict itself, and the assertion that only sleep is a factor cannot be concluded from their data as they did in fact find a relationship between annoyance and stress, but they could not conclude which one caused the other.

van den Berg, F., Pedersen, E., Bouma, J., and Bakker, R. (2008). Visual and Acoustic impact of wind turbine farms on residents. FP6-2005-Science and Society-20, Project no. 044628. A report financed by the European Union.

Thorne (2009)

As part of his research into the perception of low amplitude intrusive sound Thorne has found that there are significant differences in response between people living in rural areas near wind farms and people living in urban communities. Based on a series of sound simulations he found that the rural people interviewed found the sound of the turbines 'unpleasant, annoying and disturbing' whereas the urban community, who had not seen the wind farms or turbines, found the sounds 'pleasant and gentle'. A series of

noise sensitivity questionnaires also indicated a statistically significant difference between the two communities with the rural community more sensitive. Further research at two different locales near wind farms show that individuals initially accepting of wind farms can become increasingly sensitised to very low levels (outdoor LAeq 30 dB or less) of sound from wind farms due to the visual dominance of the turbines themselves and to noise that causes sleep disturbance or perceived adverse health effects. Sleep disturbance is caused by the varying nature of the wind farm noise; the 'rumble-thump' or 'swishing' sound heard inside the home at levels of LAeq 15 to 20 dB or less and cannot be avoided. The work of Thorne (2009) was to establish a practical methodology to integrate human perception of sound, personal sensitivity and relevant sound character analysis.

Thorne, R. (2008). Assessing intrusive noise and low amplitude sound. PhD thesis available online from Massey University, Palmerston North, New Zealand.

Jabben (2009)

Jabben and colleagues (2009) from RIVM, the Dutch National Institute for Public Health and Environment, were commissioned by the Dutch Government to examine the impact of different values of loudness on the ability to meet targets for onshore wind power generation. They reviewed current evidence and noted that, at present, 440,000 inhabitants (2.5% of the population) were *"receiving significant noise contribution from wind turbine noise of which 1,500 are expected to suffer severe annoyance. It is remarkable that almost half of this number already occurs within the range Lden 30-40db(A)"*.

Jabben J, Verheijen E and Schreurs E. 2009. Impact of wind turbine noise in the Netherlands. Third International Meeting on Wind Turbine Noise, Aalborg 17-19 June 2009.

Pierpont (2009)

Pierpont (2009) has recently completed a very detailed case-series study of ten families around the world who have been so affected by wind turbine noise that they have had to leave their homes, nine of them permanently. The turbines ranged from 1.5 to 3MW capacity at distances between 305 to 1500m. The group comprised 21 adults, 7 teenagers and 10 children of whom 23 were interviewed. While this is a highly selected group, the ability to examine symptoms before, during and after exposure to turbine noise gives it a strength rarely found in similar case-series studies. The subjects described the symptoms of wind turbine syndrome outlined above and confirmed that they were not present before the turbines started operation and resolved once exposure ceased. There was a clear relationship between the symptoms, even in children, and the noise exposure. Pierpont reports also that all (actually 14 of 21) adult subjects reported *"feeling jittery inside"* or *"internal quivering"*, often accompanied by anxiety, fearfulness, sleep disturbance and irritability. Pierpont hypothesises that these symptoms are related to low frequency sound and suggests physiological mechanisms to explain the link between turbine exposure and the symptoms.

Of particular concern were the observed effects on children, include toddlers and school and college aged children. Changes in sleep pattern, behaviour and academic performance were noted. Seven of the ten children had a decline in their school performance while exposed to wind turbine noise which recovered after exposure ceased. In total, 20 of 34 study subjects reported problems with concentration or memory.

Pierpont's study mostly addresses the mechanism for the health problems associated with exposure to wind turbine noise rather than the likelihood of an individual developing symptoms. Nevertheless, it convincingly shows that wind turbine noise is strongly associated with the symptoms she describes, including sleep disturbance. She concludes by calling for further research, particularly in children, and a two-kilometre setback distance. A recent paper (Todd et al, 2008) has shown that the vestibular system in the human ear, the part concerned with detection of movement and balance, is exquisitely sensitive to vibration at frequencies of around 100 Hz. Pierpont claims that these findings support her hypotheses.

Pierpont N. (2009). Wind Turbine Syndrome: A Report on a Natural Experiment. K Selected Publications. Santa Fe, New Mexico.

Nissenbaum (2010)

Nissenbaum (2010) has presented the preliminary results of a study of residents living downwind and within 300-1100m (mean 800m) of a wind farm at Mars Hill, Maine, USA. The 28 1.5MW turbines are sited on a 200m high ridge overlooking the homes. Thus far 22 of about 35 adult residents have been interviewed and compared with a randomly selected control group living approximately six kilometres away. Of the 22, 18 report new or worsened sleep onset disturbance at least twice a week, for 9 at least 5 times per week (controls 1/28). A further eight of the 22 report new or worsened headaches (controls 1/28) and 18/22 reported new or worsened mental health symptoms (stress 12/22; anger 18/22; anxiety 8/22; hopelessness 12/22; depression 10/22; controls 0/28).

The 22 subjects received 15 new or increased prescriptions from their physicians in the 18 months between the start of turbine operation and the study, the majority for psychoactive medication (control group: 4 prescriptions, none for psychoactive medication). All but one of the 22 participants have reported reduced quality of life and 20 are consider moving away (controls: 0/28 for both). The study may be criticised for it's relatively small numbers of subjects but the presence of a control group, well matched for age and gender, adds considerable power. All differences between the groups are statistically highly significant. The turbine noise levels at this site may be enhanced by the high concentration of turbines and the geography but the severe sleep disturbance, psychiatric symptomatology and increased medication requirement in the study group confirms the potential of wind turbine noise to adversely affect health at distances claimed to be safe.

Nissenbaum, M. A. (2010). Industrial Wind Turbines and Health Effects in Mars Hill, Maine, A Retrospective Controlled Study – Preliminary Findings as of November, 2009. Personal Communication.

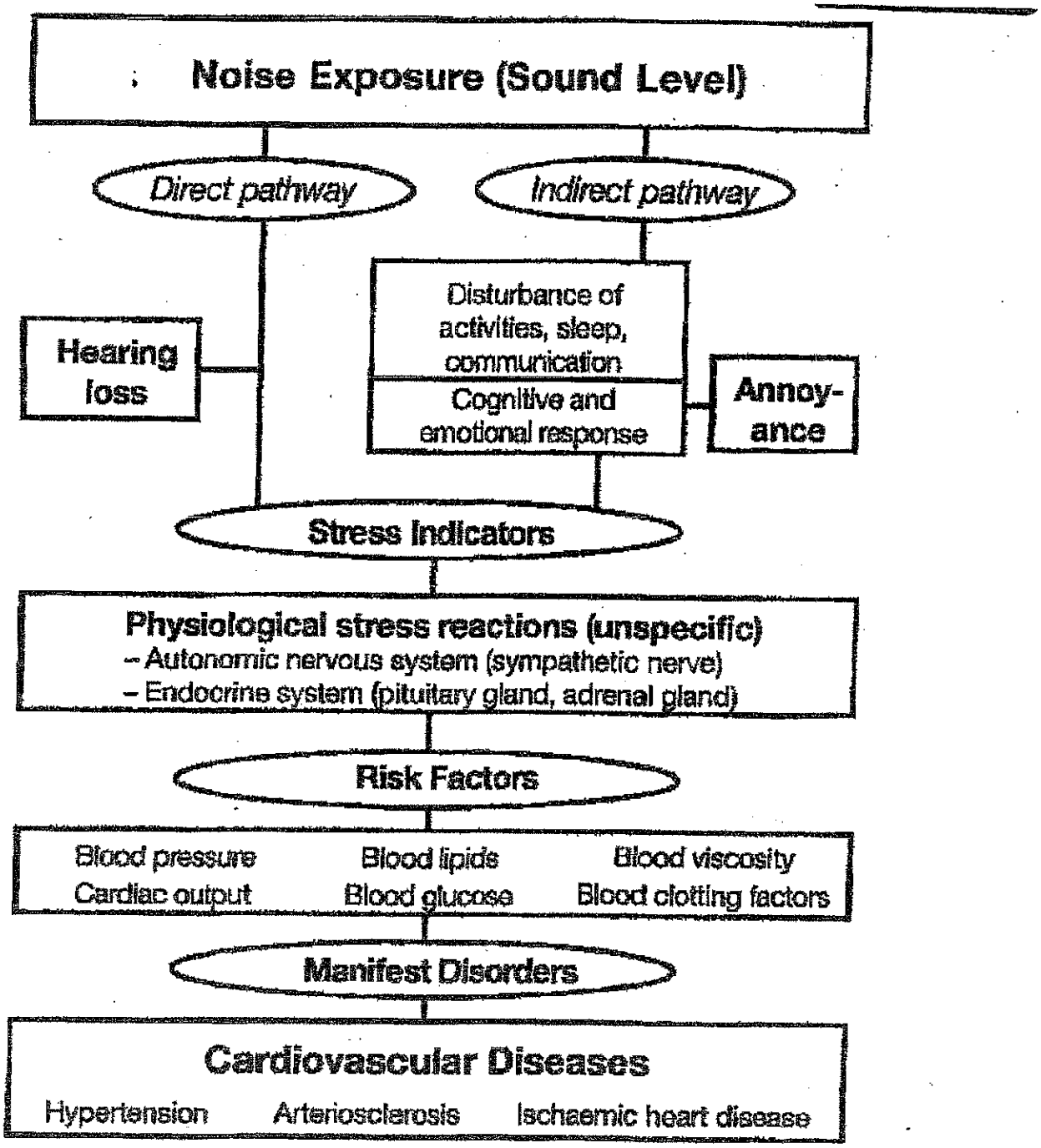

Noise Exposure (Sound Level)
Direct pathway
Indirect pathway
Hearing loss
Disturbance of activities, sleep, communication
Cognitive and emotional response
Annoy-ance
Stress Indicators
Physiological stress reactions (unspecific)
– Autonomic nervous system (sympathetic nerve)
– Endocrine system (pituitary gland, adrenal gland)
Risk Factors
Blood pressure
Cardiac output
Blood lipids
Blood glucose
Blood viscosity
Blood clotting factors
Manifest Disorders
Cardiovascular Diseases
Hypertension
Arteriosclerosis
Ischaemic heart disease

EXHIBIT D

THRESHOLDS FOR OBSERVED EFFECTS

The no observed adverse effect level (NOAEL) is a concept from toxicology, and is defined as the greatest concentration which causes no detectable adverse alteration of morphology, functional capacity, growth, development or lifespan of the target organism. For the topic of night noise (where the adversity of effects is not always clear) this concept is less useful. Instead, the observed effect thresholds are provided: the level above which an effect starts to occur or shows itself to be dependent on the exposure level. It can also be a serious pathological effect, such as myocardial infarctions, or a changed physiological effect, such as increased body movement.

Threshold levels of noise exposure are important milestones in the process of evaluating the health consequences of environmental exposure. The threshold levels also delimit the study area, which may lead to a better insight into overall consequences. In Tables 1 and 2, all effects are summarized for which *sufficient and limited evidence* exists. For these effects, the threshold levels are usually well known, and for some the dose-effect relations over a range of exposures could also be established.

Effect		Indicator	Threshold, dB
Biological effects	Change in cardiovascular activity	*	*
	RBG awakening	$L_{max,outside}$	35
	Motility, onset of motility	$L_{max,outside}$	32
	Changes in duration of various stages of sleep, in sleep structure and fragmentation of sleep	$L_{max,outside}$	35
	Waking up in the night and/or too early in the morning	$L_{max,outside}$	42
Sleep quality	Prolongation of the sleep inception period, difficulty getting to sleep	*	*
	Sleep fragmentation, reduced sleeping time	*	*
	Increased average motility when sleeping	$L_{night,outside}$	42
Well-being	Self-reported sleep disturbance	$L_{night,outside}$	42
	Use of somnifacient drugs and sedatives	$L_{night,outside}$	40
Medical conditions	Environmental insomnia**	$L_{night,outside}$	42

Table 1 Summary of effects and threshold levels for effects where *sufficient* evidence is available

* *Although the effect has been shown to occur or a plausible biological pathway could be constructed, indicators or threshold levels could not be determined.*

** *Note that "environmental insomnia" is the result of diagnosis by a medical professional whilst "self-reported sleep disturbance" is essentially the same, but reported in the context of a social survey. Number of questions and exact wording may differ.*

Average night noise level over a year $L_{night,outside}$	Health effects observed in the population
Up to 30 dB	Although individual sensitivities and circumstances may differ, it appears that up to this level no substantial biological effects are observed. $L_{night,outside}$ of 30 dB is equivalent to the no observed effect level (NOEL) for night noise.
30 to 40 dB	A number of effects on sleep are observed from this range: body movements, awakening, self-reported sleep disturbance, arousals. The intensity of the effect depends on the nature of the source and the number of events. Vulnerable groups (for example children, the chronically ill and the elderly) are more susceptible. However, even in the worst cases the effects seem modest. $L_{night,outside}$ of 40 dB is equivalent to the lowest observed adverse effect level (LOAEL) for night noise.
40 to 55 dB	Adverse health effects are observed among the exposed population. Many people have to adapt their lives to cope with the noise at night. Vulnerable groups are more severely affected.
Above 55 dB	The situation is considered increasingly dangerous for public health. Adverse health effects occur frequently, a sizeable proportion of the population is highly annoyed and sleep-disturbed. There is evidence that the risk of cardiovascular disease increases.

Table 3
Effects of different levels of night noise on the population's health

A number of instantaneous effects are connected to threshold levels expressed in L_{Amax}. The health relevance of these effects cannot be easily established. It can be safely assumed, however, that an increase in the number of such events over the baseline may constitute a subclinical adverse health effect by itself leading to significant clinical health outcomes.

Based on the exposure-effects relationship summarized in Table 3, the night noise guideline values are recommended for the protection of public health from night noise as below.

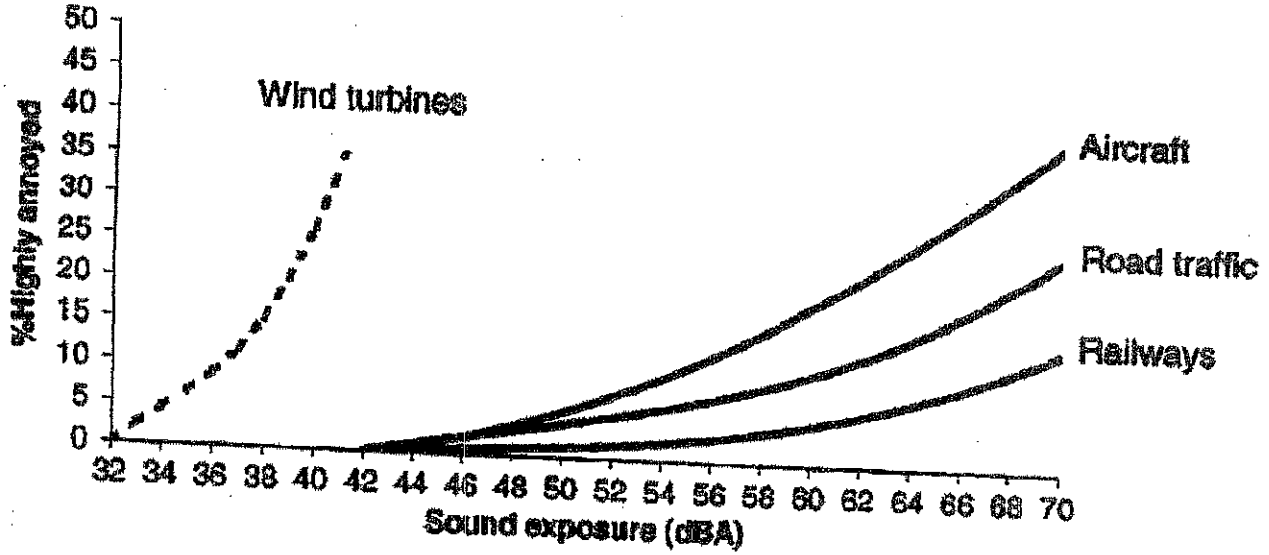
Night noise guideline (NNG)	$L_{night,outside}$ = 40 dB
Interim target (IT)	$L_{night,outside}$ = 55 dB

Table 4
Recommended night noise guidelines for Europe

[1] $L_{night,outside}$ is the night-time noise indicator (L_{night}) of Directive 2002/49/EC of 25 June 2002: the A-weighted long-term average sound level as defined in ISO 1996-2: 1987, determined over all the night periods of a year; in which: the night is eight hours (usually 23.00 – 07.00 local time), a year is a relevant year as regards the emission of sound and an average year as regards the meteorological circumstances, the incident sound is considered, the assessment point is the same as for L_{den}. See *Official Journal of the European Communities*, 18.7.2002, for more details.

EXHIBIT 3

Percent of Community Highly Annoyed



E. Pedersen and K. P. Waye, Perception and annoyance due to wind turbine noise—a dose–response relationship. J. Acoustical. Soc. Am. 116 (6), December 2004, pp. 3460–3470.

Exhibit F

Industrial Wind Turbines
Adverse Health Effects?

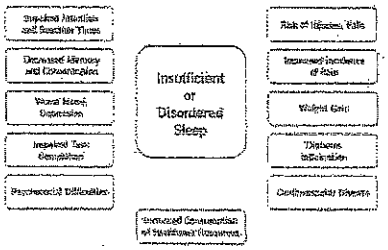
Do IWT's in proximity to homes result in Sleep Deprivation?

If so, what can we do to make sure they do not cause sleep disturbance?

Michael A. Nissenbaum, MD

THE CENTER FOR HEALTH DESIGN® Research Coalition

2010



Jo M. Solet, PhD, Orfeu M. Buxton, PhD, Jeffrey M. Ellenbogen, MD
Harvard Medical School, Division of Sleep Medicine

UC San Diego HEALTH SYSTEM

Brain Activity is Visibly Altered Following Sleep Deprivation ; 7/2002

http://health.ucsd.edu/news/2000_02_09_Sleep.html

Sleep Deprivation

⇩

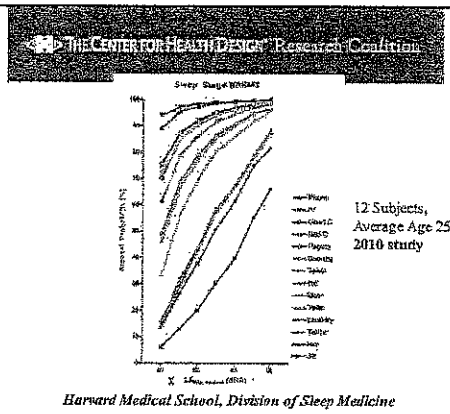
Illness

'Settled Science'

Sleep Deprivation

FACT:

Sleep Deprivation is a SERIOUS Adverse Health Effect



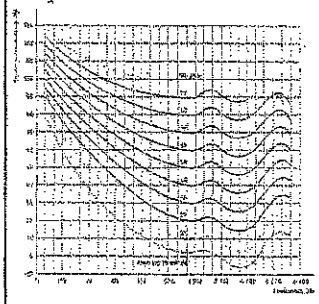
How does the pitch and pattern of a signal affect auditory arousal thresholds?

DOROTHY BRUCK[1], MICHELLE HALL[1], IAN THOMAS[2] and VINCENT BOUILLARD[3]

"Pure tones at equivalent amplitudes are significantly less effective than complex tones at awakening people."

A complex tone is perceived as louder (up to 10 db at 20 HZ) than a pure tone, though the sound meter will register the same dB level!

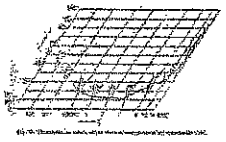
Equal Loudness Contours

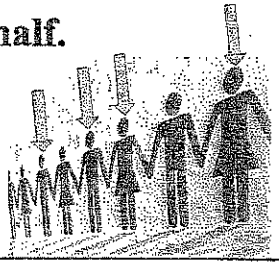


Hearing Contours for Equal Loudness Level (ISO 2003) from ARCanREA 12/2009 "White Paper"

These are made with pure tones only, and reflect *average* values only

One half of the people in this room will be more sensitive to noise than the other half.

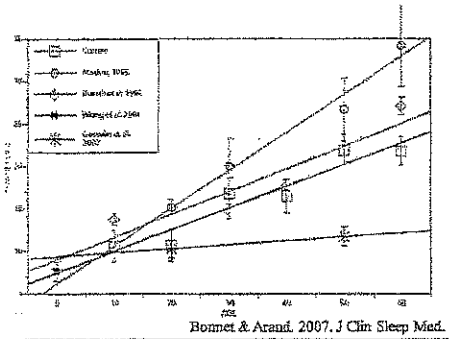




Arousals and noise

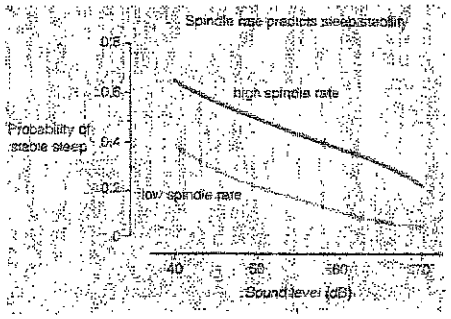
- Likelihood of arousal depends upon:
  - Sound pressure
  - Sound character and content
  - Sleep stage
  - Age
  - Individual propensity (spindle density)

Arousal Index and Age



Bonnet & Arand. 2007. J Clin Sleep Med. 3

Spindle rate and noise induced arousals



Dang-Vu et al. 2010. Current Biology

Low-frequency noise from large wind turbines

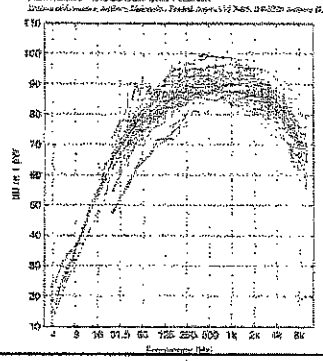
Henrik Møller[a)] and Christian Sejer Pedersen
Section of Acoustics, Aalborg University, Fredrik Bajers Vej 7-B5, DK-9220 Aalborg Ø, Denmark

Even when A-weighted levels are considered, a substantial part of the noise is at low frequencies, and for several of the investigated large turbines, the one-third-octave band with the highest level is at or below 250 Hz. It is thus beyond any doubt that the low-frequency part of the spectrum plays an important role in the noise at the neighbors.

J. Acoust. Soc. Am., Vol. 129, No. 6, June 2011

Low-frequency noise from large wind turbines

Henrik Møller[a)] and Christian Sejer Pedersen

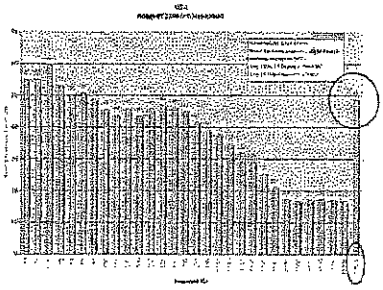


A-weighted apparent sound power levels in one-third-octave bands.

Forty-five turbines with nominal electric power 75 kW–3.6 MW.

Mars Hill, Midnight

Turbine at ½ power

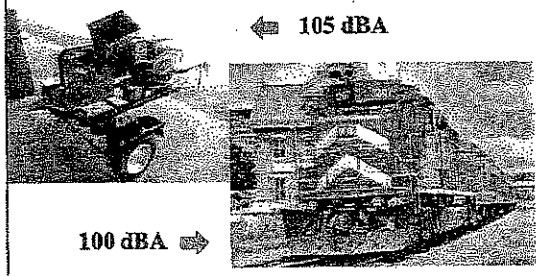


1 hr. avg

Most sound energy from turbines is found at low frequencies

Sound Travel

105 dBA



100 dBA

lower frequencies travel farther

The World Health Organization is one of the bodies which recognizes the special place of low frequency noise as an environmental problem. Its publication on Community Noise (Berglund et al., 2000) makes a number of references to low frequency noise, some of which are as follows:

- *" It should be noted that low frequency noise . . . can disturb rest and sleep even at low sound levels"*
- *"For noise with a large proportion of low frequency sounds a still lower guideline (than 30dBA) is recommended"*
- *"It should be noted that a large proportion of low frequency components in a noise may increase considerably the adverse effects on health"*
- *"The evidence on low frequency noise is sufficiently strong to warrant immediate concern"*

A Review of Published Research on

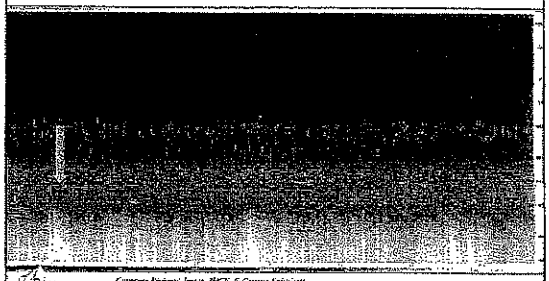
Low Frequency Noise and its Effects

Wind Turbine Sound and Health Effects

An Expert Panel Review

Outdoors 3 A.M.

Modern 1.5 MW GE turbine at 1500 feet



Courtesy Robert Jones, BKE, E-Coustic Solutions

A Review of Published Research on Low Frequency Noise and its Effects 2003

There is clear evidence that the brain is able to adapt to stimuli.

If sufferers spend a great deal of time listening to, and listening for, their particular noise, it is possible that they may develop enhanced susceptibility to this noise.

Enhanced susceptibility is therefore a potential factor in low frequency noise problems.

[Long Term Potentiation, 'plasticity']

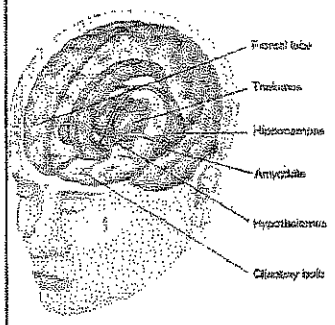
What about 'Habituation'?

"The auditory system is an alerting system, ideally it should never sleep and never habituate." Daniel Shepherd, Ph.D, Psychophysiologist,

'Long Term Potentiation':

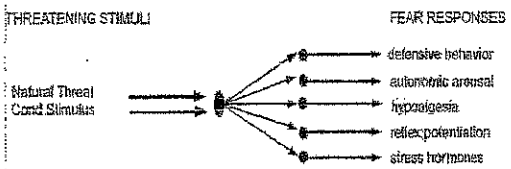
Repetitive fear inducing auditory stimuli result in increasing amplitude of reaction, over time. Similar to a learned response.

LeDoux, Emotion Circuits in the Brain, Annu. Rev. Neurosci. 2000. 23:155–184



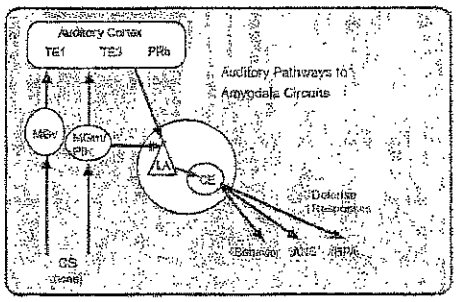
Auditory stimuli are known to affect the amygdala via both cortical and subcortical (thalamic) pathways

LeDoux et al, 1990
Mascagni et al 1993
McDonald 1998
Romanski and LeDoux 1992, 1993

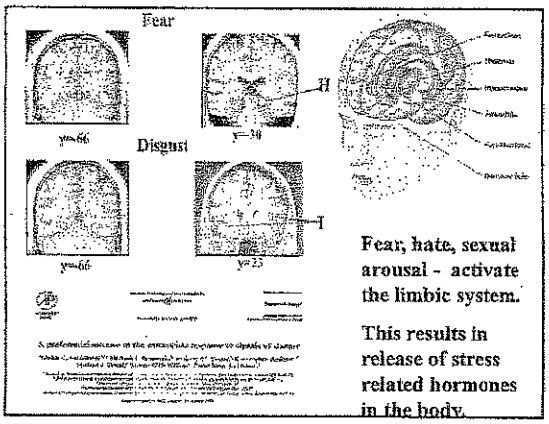


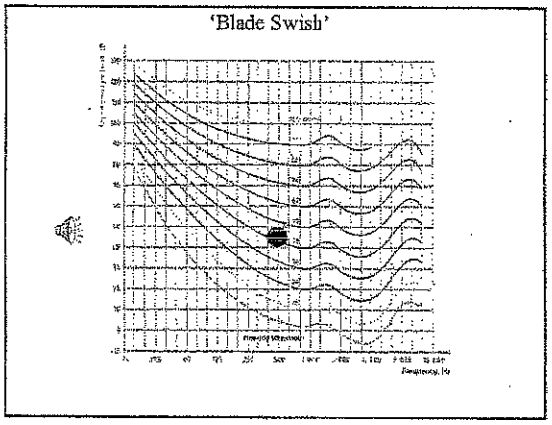
From LeDoux, Emotion Circuits in the Brain, Center for Neural Science, NYU
Annu. Rev. Neurosci. 2000. 23:155–184in

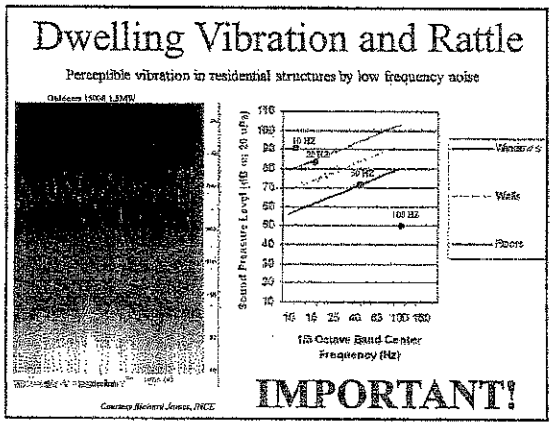
Neural pathways involved in fear conditioning



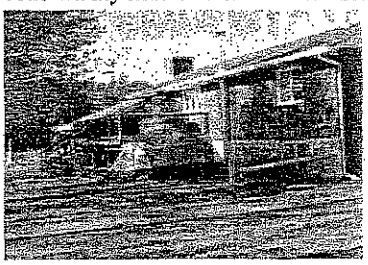
LA=Lateral Amygdala, CE=Central Amygdala, HPA=Hypothalamic Pituitary Axis, ANS=Autonomic Nervous System, TE1=Primary Auditory Cortex, TE3=Auditory Association Cortex, MG=Medial Geniculate nuclear zones


Fear
Disgust
Fear, hate, sexual arousal - activate the limbic system.
This results in release of stress related hormones in the body.


'Blade Swish'


Dwelling Vibration and Rattle
Perceptible vibration in residential structures by low frequency noise
Windows
Walls
Floors
1/3 Octave Band Center Frequency (Hz)
IMPORTANT!

'House . . . humming again tonight . . . incredibly horrible. I don't know how much of this we can take . . . reached my limit . . . there is no escape . . .'

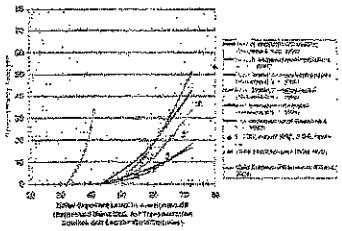


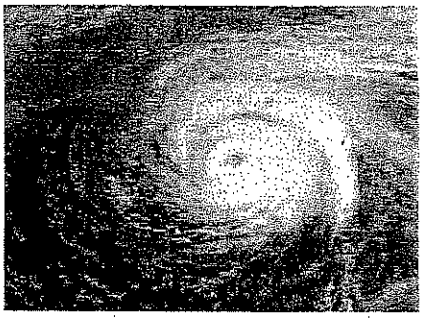
Amaranth/Melancthon Ontario:
Home eventually bought by Wind Developer

Wind Turbine Noise:

1. **Preponderance of lower frequencies** (increased audibility at distance, increased resonance within homes, increased physiologic threat/fear response, possible long term potentiation)
2. **Highly modulated** (increased engagement of the human brain, possible long term potentiation)
3. **To-date, poorly understood** (poorly regulated, poor preconstruction modeling)

Decibel for Decibel, Wind Turbine Noise IS more disturbing than other sources of industrial noise





'Perfect Storm'

Industrial Wind Turbines and Adverse Health Effects

MARS HILL, and VINALHAVEN, MAINE

A retrospective, cross-sectional epidemiological study- USA

Michael A. Nissenbaum, MD
Jeff Aramini, DVM, MSC, PhD
Christopher Hanning, BSc, FRCA, MD
Submitted for publication
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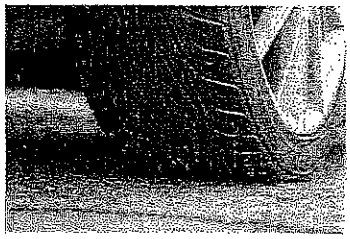


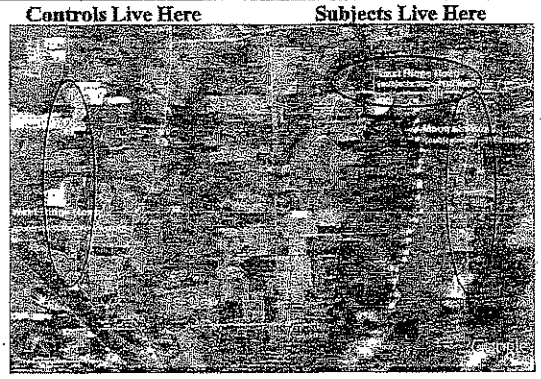
Rubber Meets Road

Objectives

Determine if there are significant associations between distance of residential homes to IWTs and:

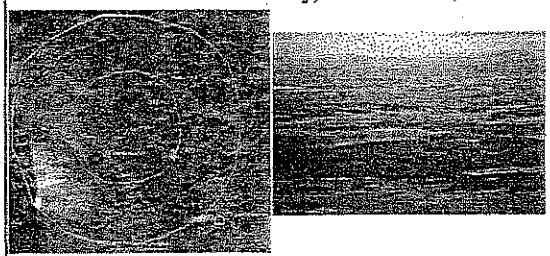
1. new or worsened sleep disturbances
2. mental health
3. physical health
4. quality of life
5. prescription medication

Controls Live Here **Subjects Live Here**



Mars Hill, Maine, Complete Mar 07

Fox Islands Wind Facility, Vinalhaven, Maine



- 3 - 1.5 MW turbines, 389 ft tall, cluster
- Online October 09
- 15/33 adults within 3500 feet interviewed

Study design

Distance to nearest IWT assessed using satellite and aerial images

Outcomes investigated:
- QualityMetric Health Outcomes SF-36v2
  - physical (PCS)
  - Mental (MCS)
- Epworth Sleepiness Scale (ESS)
- Pittsburgh Sleep Quality Index (PSQI)
- Others

Data analyst not familiar with study location and participants - reduce bias (Jeff Aramini, DVM, MPH)

Mars Hill and Vinalhaven Study

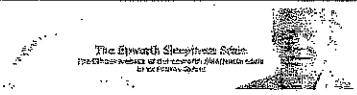
- 38 subjects within 375-1400m
- 41 subjects within 3000-6000m
- ESS, PSQI, SF36v2

No significant demographic differences between sites or between near and far distance groups

SF-36v2 Health Survey

- 36 questions measuring functional health and well-being from the patient's point of view.
- Practical, reliable (reproducible), and valid measure of physical and mental health

Is the most world's widely used Patient Reported Outcome Tool in clinical trials



A New Method for Measuring Daytime Sleepiness: The Epworth Sleepiness Scale

Murray W. Johns

The ESS is a self-administered questionnaire with 8 questions. It provides a measure of a person's general level of daytime sleepiness, or their average sleep propensity in daily life. **It has become the world standard method for making this assessment.**

University of Pittsburgh

Sleep Medicine Institute

Psychiatry Research, 28, 193-213 193
Elsevier

The Pittsburgh Sleep Quality Index: A New Instrument for Psychiatric Practice and Research

Daniel J. Buysse, Charles F. Reynolds III, Timothy H. Monk, Susan R. Berman, and David J. Kupfer

Received May 9, 1988; revised version received August 17, 1988; accepted November 23, 1988.

Fourth International Meeting on Wind Turbine Noise

Rome Italy 12-14 April 2011

Selection of outcome measures in assessing sleep disturbance from wind turbine noise

Christopher Hanning and Michael Nissenbaum

University Hospitals of Leicester, UK and Northern Maine Medical Center, USA.
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Data Analysis

Quantitative epidemiological analysis
- Multi-variate statistical modeling
- Controlling for age, gender, household clustering
- Both continuous and categorical dependent (outcome) and independent (predictor) variables
- Significance testing

Pittsburgh Sleep Quality Index vs distance to IWTs

Data presented to BEP July 7

The closer you live to IWTs, the poorer your sleep quality as measured by PSQI

Epworth Sleepiness Scale vs distance to IWTs

Data presented to BEP July 7

The closer you live to IWTs, the poorer your sleep quality as measured by ESS

Mental Component Summary Scale (MCS) vs distance to IWTs

Data presented to BEP July 7

The closer you live to IWTs, the poorer your mental health as measured by MCS

Mental Health

*Frequency x Severity

The closer you live to IWTs, the poorer your mental health as measured by self reported before & after parameters

Physical Health

The closer you live to IWTs, the more likely you are to experience physical illness

Medications

Data presented to BEP July 7

The closer you live to IWTs, the more likely you are to be clinically diagnoses with depression/anxiety and offered medication.

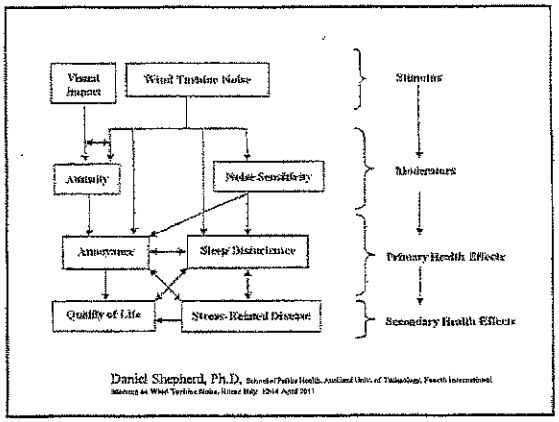
Subjective Quality of Life

Data presented to BEP July 7

*Strongly agree=1; Strongly disagree=5

The closer you live to IWTs, the more likely you feel that your quality of life has deteriorated.

Alleged School Bus Accident
(not peer reviewed)



What we see at Mars Hill and Vinalhaven is fully understandable, given:

- **current legal limits as goals**
- **modeling systems/errors**
- **known human physiology**

Solutions:

1. **Reform legal limits (eg: baseline +)**
2. **Fix modeling**

Solutions:

3. **Understand and accept human physiological realities**